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Comparative Evaluation on Properties of Hybrid Glass Fiber- Sisal/Jute Reinforced Epoxy Composites

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Abstract

The incorporation of natural fibres such as sisal/jute with glass fiber composites has gained increasing applications both in many areas of Engineering and Technology. The aim of this study is to evaluate mechanical properties such as tensile and flexural properties of hybrid glass fiber-sisal/jute reinforced epoxy composites. Microscopic examinations are carried out to analyze the interfacial characteristics of materials, internal structure of the fractured surfaces and material failure morphology by using Scanning Electron Microscope (SEM). The results indicated that the incorporation of sisal fiber with GFRP exhibited superior properties than the jute fiber reinforced GFRP composites in tensile properties and jute fiber reinforced GFRP composites performed better in flexural properties.

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Keywords: Jute/sisal Glass fiber-sisal/jute reinforced epoxy composites; Tensile properties; Flexural properties; Scanning Electron Microscope

1. Introduction

Natural fibers exhibit superior mechanical properties such as flexibility, stiffness and modulus compared to glass fibers [1]. In the recent days natural fibers such as sisal and jute fibers are replacing the glass and carbon fibers owing to their easy availability and cost [2]. The layer sequence has greater effect on flexural and inter laminar shear properties and placing the GFRP layers at the ends possess good mechanical strength [3]. Sisal/jute fiber composites are environment friendly and user-friendly materials [4] and have very good elastic properties [5]. Yan Li et al [6] studied that sisal fiber is the promising reinforcement because of low density, high specific strength, no health hazards and finding applications in making of ropes, mats, carpets, fancy articles etc. Tensile properties of palm/jute fiber reinforced polymer hybrid composites are carried out by Jawaid et al [7]. They have prepared hybrid natural fiber composites taking palm fiber as skin and jute as core material. They observed that the tensile properties slightly higher for the jute as skin and palm fiber as core material.

Jawaid et al [8] conducted experiment on effect of jute fiber loading on tensile and dynamic mechanical properties of oil palm composites. They have identified that the tensile properties of jute oil palm fiber hybrid composites are increased substantially with increasing the content of jute fibres loading as compared to oil palm–epoxy composites. The strength properties of natural fiber composites are somewhat lower, because of less stiff and typically less brittle. Reinforcing glass fiber into the sisal–polypropylene composites enhanced tensile and flexural properties without any effect on tensile and flexural module. In addition to this, adding sisal fiber with glass fiber improves thermal properties and water resistance of the hybrid composites [9].

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Maries Idicula et al [10] investigated the mechanical properties of banana/sisal hybrid fiber reinforced polyester composites. They are taking volume fraction of the fiber content as prime factor and observed that the highest tensile and flexural modulus at 0.4 volume fraction and also indicated the sisal/polyester composite having maximum damping value and impact strength than banana fiber polyester hybrid composites. The sisal/banana hybrid natural fiber composite specimens are prepared with different ratios by taking 0.4 volume fraction and tensile properties of these hybrid natural fiber composites are examined by using Rule of Hybrid Mixture (RoHM) [11]. It was predicted the RoHM equation gives the tensile properties of the hybrid composites slightly higher than the experimental values. Murali Mohan Rao et al [12] have also taking the same factor and they reported the tensile properties of vakka fiber composites increase with volume fraction of fiber and more than the sisal/banana fiber composites. Whereas the flexural properties of vakka fiber composites are closer to the sisal fiber composites and more than that of the banana fiber composites.

Venkateswaran et al [13] studied the mechanical and water absorption properties of banana/sisal reinforced hybrid composites for taking the length of the fiber and weight percentage as main constituent. They have reported the hybridization of sisal fiber with banana/epoxy composites up to 50% by weight increasing the mechanical properties and decreasing the water absorption properties. The overall tensile and flexural properties of natural fiber reinforced polymer hybrid composites are highly dependent on the aspect ratio, moisture absorption tendency, morphology and dimensional stability of the fibers used. The tensile and flexural properties of chemically treated natural fiber composites are slightly improved than the non-treated composites [14].

Panthapulakkal and Sain [15] analyzed the mechanical and thermal properties of hemp/glass fiber-polypropylene (PP) composite materials. The results indicated that the reinforcement of hemp fiber with glass fiber hybrid composite material improve the flexural, impact properties and water resistance. In addition they have observed that the addition of glass fiber into hemp-PP composites resulted in improved thermal properties as well as the water resistance of the composites. In this investigation sisal-glass epoxy and jute-glass epoxy composites is fabricated and their mechanical properties are compared and presented in detail.

2. Experimental

2.1. Materials

In this experiment, for fabricating the composites specimen Sisal (Agave sisalana), Jute (Corchorus oliotorus) and Glass fibers are used. The raw sisal and jute fibers are collected in the form of residues from Dharmapuri District, Tamil Nadu, India. The epoxy resin and hardener Tri Ethylene Tetra Amine (TETA) are provided by M/s. Sakthi fiberglass Ltd., Chennai, India. The Glass-Fiber of bi-directional woven mat with 600gsm is used for the fabrication of specimen. The physical properties of the natural fibers are presented in Table 1.

Table 1 Physical properties of Natural fibers (Sisal and Jute)

Physical property	Sisal fiber	Jute fiber
Density(g/cm^3)	1.34	1.48
Tensile Strength(kN/mm^2)	610-720	410-780
Stiffness (kN/mm)	30-38	10-30
Elongation at break(%)	2-3	1.9
Moist Absorption(%)	11	12
Price of raw fiber(Rs./kg)	60-70	40-50

2.2. Preparation of composite specimen

The materials used for the experiment is prepared by hand layup process. Raw sisal and jute fibers of 35mm length are used specimen preparation. The lamina consisting of three layers of glass fibers and two layers of natural fibers. Initially the fibers are dried under sunlight for 3 to 5 hours. The first layer is the glass fiber, fill the epoxy resin over the glass fiber and then fill the natural fiber over the resin before the resin get dried and the subsequent layers are filled. The air gaps formed between the layers during fabrication are gently squeezed out by using roller. Finally these laminas are kept in press, for over 24 hours to get the perfect shape and thickness. The thickness of the lamina is limited to 5mm and the size is 30x30 cm. After dried, the edges of the specimen are neatly cut by using saw as per the required dimensions.

2.3. Mechanical Properties of Composites

2.3.1. Tensile test

The edges of the specimen are finished by using file and emery paper for tensile testing. There are two different types of specimen are prepared, the first specimen consists of Sisal/GFRP fibers and the second is of Jute/GFRP fibers. The specimen preparation, dimensions, gauge length and speeds are according to the ASTM D638 standard. The test is performed on the Universal Testing Machine (UTM) and the surrounding temperature is 35ºC. A tensile test specimen placing in the testing machine and applying load until it fractures. Due to the application of load, the elongation of the specimen is recorded. The experiments are repeated for three times and the average values are used for presentation.

2.3.2. Flexural test

Preparation of the flexural test specimens as per the ASTM D790 standards and 3-point flexure test is used for testing. The deflection of the specimen is measured and the tests are carried out at an average relative humidity of 50% and the temperature about 35ºC. From the testing machine the flexural load as well as the displacements are recorded for all the test samples.

3. Results and discussion

In this study natural fibers are added to the glass fiber and their effect on tensile and flexural properties are evaluated and compared. The results for the tensile and flexural testing of the hybrid composite samples are given in Table 2.

Table 2.Tensile and flexural properties of different composite samples (Average of Three samples)

Sample	Tensile Load (MPa)	Flexural Load (KN)	Displacement (mm)
Sisal/GFRP Composite	68.55	0.92	7.43
Jute/GFRP Composite	62.99	1.03	6.16

3.1 Tensile properties

The composite samples are tested in the universal testing machine (UTM) and the stress-strain curve is plotted. The typical graph generated directly from the machine for tensile test for sisal/GFRP is presented in Fig. 1. and for jute/GFRP is presented in Fig. 2.

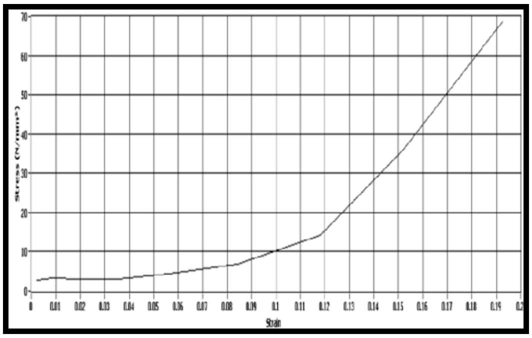

Fig. 1. Stress strain curve for tensile test in sisal/GFRP composite

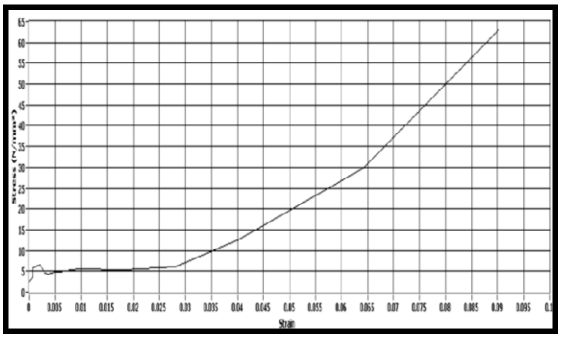

Fig. 2. Stress strain curve for tensile test in jute/GFRP composite

The ultimate tensile strength (UTS) of the different composite samples are tested and presented in Fig 3. The results indicated that the ultimate tensile strength of the sisal/GFRP composite is slightly higher than the jute/GFRP composites.

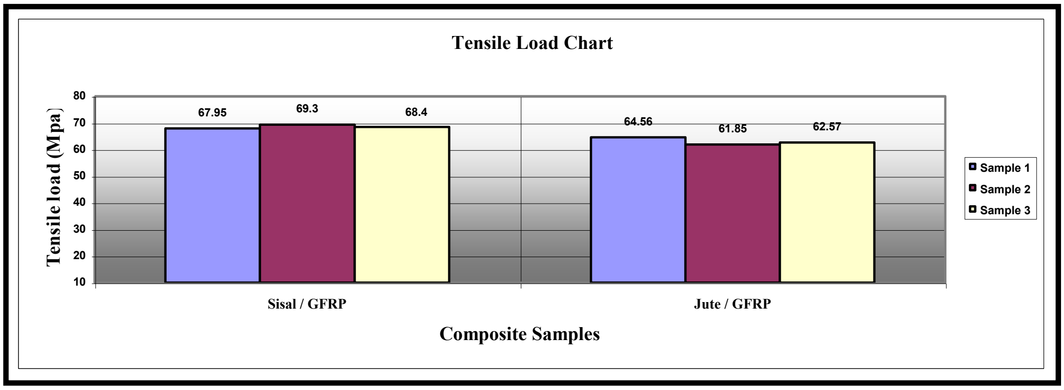

Fig. 3. Tensile load comparison of different composite samples

3.2 Flexural properties

The flexural properties of the composite samples tested in the UTM and the typical stress-strain curve generated for sisal/GFRP composite sample is presented in Fig 4. and for jute/GFRP sample is presented in Fig 5.

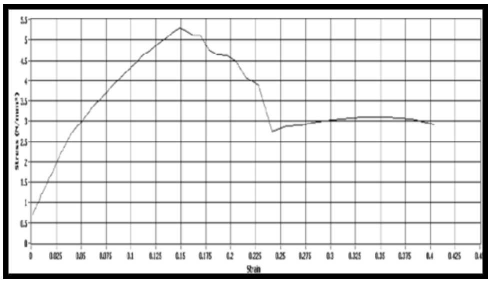

Fig. 4. Stress strain curve for flexural test in sisal/GFRP composite

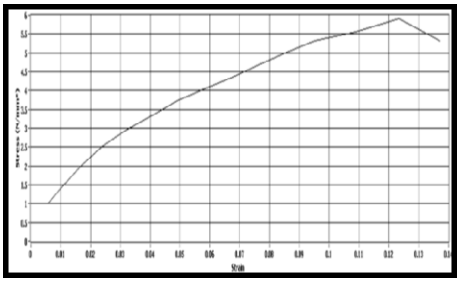

Fig. 5. Stress strain curve for flexural test in jute/GFRP composite

The flexural load for different composite samples are observed and presented in Fig 6. From the figure, it is asserted that the flexural load carrying capacity of jute/GFRP composites is better than sisal/GFRP composites tested.

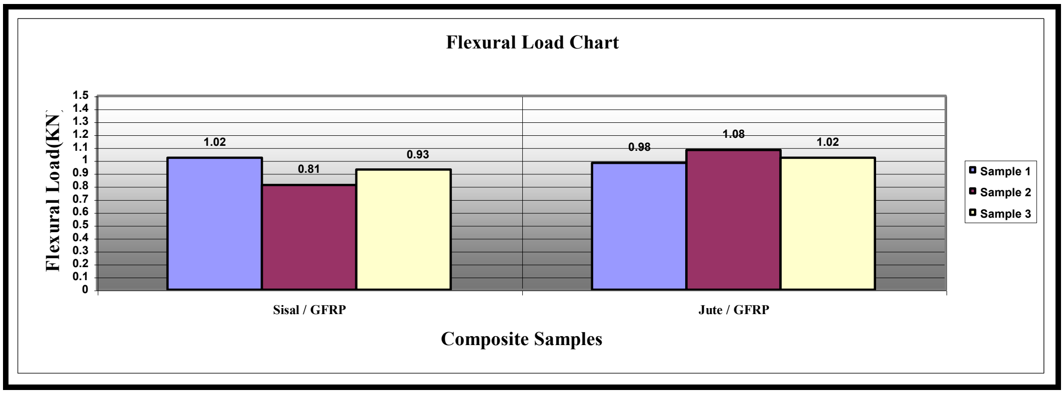

Fig.6. Flexural load comparison of different composite samples

From the results, it has been noted that the tensile and flexural strength of GFRP composites is better than the composites tested. Even though the GFRP composites are performing better, the natural fibers reduce the environmental risk and other advantages. Hence these work tensile and flexural studies are carried out for sisal/GFRP and jute/GFRP composites.

3.3.Scanning Electron Microscopy (SEM) Analysis

The failure morphology of the composite samples used for the experiment is examined through scanning electron microscopy. The SEM image of the samples underwent tensile test is presented in Fig 7. The fracture takes place in the specimen by the application of the tensile load. The figure indicates the fiber fracture and pull out from the specimen and also the dislocation of fibers.

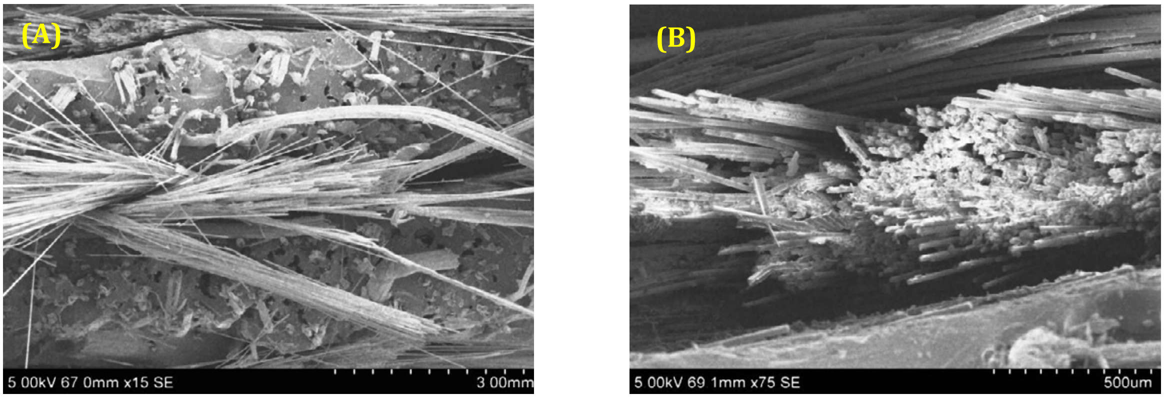

Fig.7. SEM images of (A) Sisal/GFRP composite sample(B) Jute/GFRP composite sample underwent tensile test

The SEM image of the samples underwent flexural test is presented in Fig 8. Due to the application of flexural load on the specimen, the fibers are separated from the resin as shown in the figure.

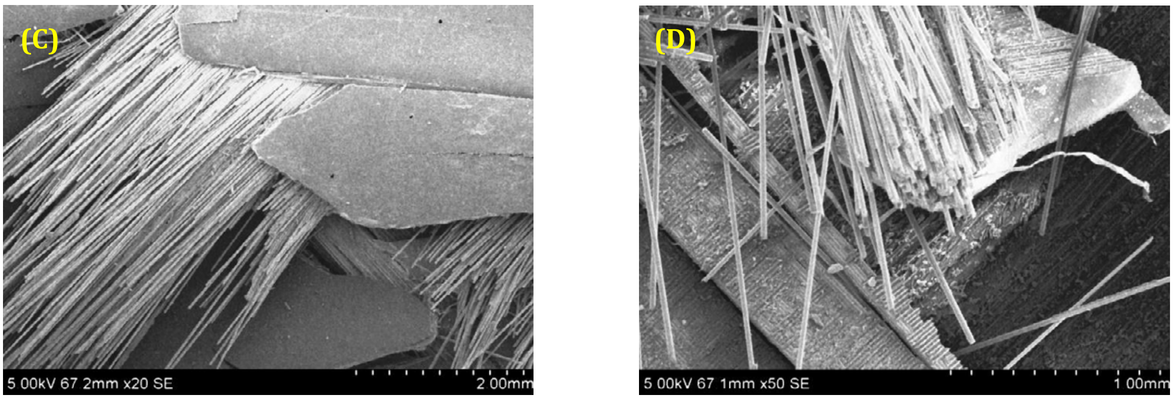

Fig.8. SEM image of (C) Sisal/GFRP composite sample (D) Jute/GFRP composite sample underwent flexural test

4. Conclusion

The sisal/GFRP and jute/GFRP hybrid composite specimens are prepared and subjected to tensile and flexural loading. From the experiment, the following conclusions are derived.

- The sisal/GFRP composite samples possess good tensile strength and can withstand the strength up to 68.55 MPa.
- The jute/GFRP composite specimen is holding the maximum flexural load of 1.03KN slightly higher than the sisal/GFRP composite sample.
- The failure morphology of the tested samples is examined by using Scanning Electron Microscope.

- From the results, it can be concluded that sisal-GFRP composites performing better for tensile loading and jute-GFRP composites performing better for flexural loading.
- The performance of these natural fiber composites is lower than that of the GFRP, it has been used in many application which requires medium strength.

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